Magnetostrictive Torque Motor

Problem Definition and Project Planning

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Overview

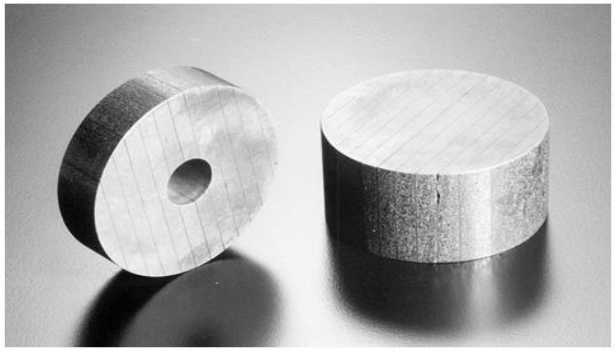
- Introduction
- Need Statement
- Problem Definition
    - Project Goal
    - Objectives
    - Constraints
- Quality Function Deployment
- House of Quality
- Project Plan
- State-of-the-Art Research
- Conclusions

Introduction

- Honeywell Aerospace designs and manufactures numerous products and services for the commercial and military aircraft industry
- Michael McCollum is Chief Engineer of Pneumatic controls technology for Honeywell
- Mitchell Thune is a recent NAU graduate who is working with Michael McCollum on this project
- The clients want to replace an electromagnetic transducer with a magnetostrictive material, Terfenol-D, in the pneumatic control systems used on commercial airliners

Introduction

- Terfenol-D, designed by the U.S. Navy, elongates when placed in a magnetic field and this elongation produces a force
- Terfenol-D is generally manufactured in round bars, as shown below



Source: Etrema.com

Need Statement

Currently, there are no feasible actuators for aircraft valve systems using the magnetostrictive material Terfenol-D.

Project Goal

The goal of this project is to develop a viable actuator that applies the magnetostrictive properties of Terfenol-D.

Objectives

Objective	Measurables	Units
Decrease Hysteresis Effect	Magnetic Field Strength	A/m*
Increase Strain	Percent Elongation	in/in
Measure Output Force	Force	lbf
Reduce Operation Time	Time	milliseconds
Maximize Work Per Unit Weight	Work, Weight	ft^2/s^2

* English units for magnetic field are not well-defined.

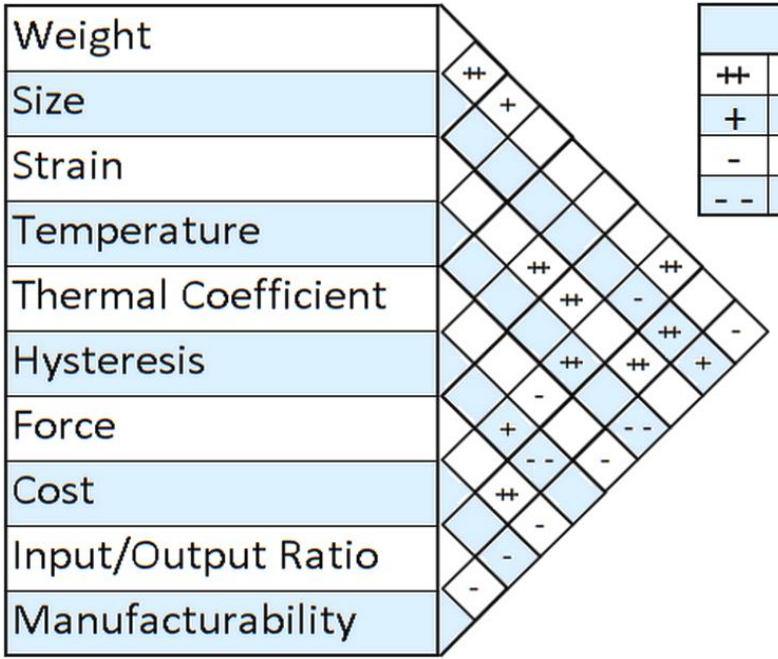
Constraints

- At least 25 lb of force exerted
- Need at least 0.03 in stroke (based off of 3 in length rod)
- Must cost less than $5000 USD
- Must be smaller than 3 x 5 x 12 in
- Coefficients of thermal expansion must be constant throughout device
- System must be cooler than 500 °F
- Greater than 1:10 ratio of input to output distances

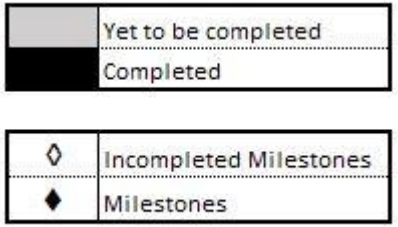
Quality Function Deployment

Customer Requirements \ Engineering Requirements	Weight	Size	Strain	Temperature	Thermal Coefficient	Hysteresis	Force	Cost	Input/Output Ratio	Manufacturability
Inexpensive	◊	◊						◊		◊
Durable	◊			◊	◊			◊		◊
Efficient	◊	◊				◊	◊			
Quick			◊			◊	◊			
Small	◊	◊						◊	◊	◊
Reliable					◊	◊	◊	◊	◊	
Feasible	◊	◊	◊	◊		◊	◊	◊	◊	◊
Simple						◊		◊	◊	◊
High Stroke		◊	◊			◊		◊	◊	
Heat Tolerant				◊	◊			◊		◊

House of Quality



Project Plan



Activity	Schedule (In weeks) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Preliminary Research																
Gather Materials																
Design System																
Draft Designs																
Design Selection																
Create Proof of Concepts Prototype																
Re-design																
Testing																
Material Data Collection																
System Data Collection																
Milestones																
Client Meetings			♦				◊				◊				◊	
Problem Definition and Project Plan				◊												
Concept Generation and Selection								◊								
Proof of Concept Presentation												◊				
Project Proposal															◊	

State-of-the-Art Research

- Solenoid Design Presentation - Michael McCollum, Lecture of Pneumatic Controls
- Electromagnetic Devices - H.C. Rotors, book published in 1941 focusing on magnetic machines
- Various articles gathered from several databases (Engineering Compendex, WorldCat, and Google Scholar)
- Dissertation on Terfenol-D from Ohio State University
- Dr. C. Ciocanel - Faculty reference on Smart Materials

Conclusions

- We are designing an actuator for Honeywell that incorporates Terfenol-D, a magnetostrictive material
- Michael McCollum and Mitchell Thune are our contacts at Honeywell
- Need to determine feasibility of using Terfenol-D in aircraft valve systems
- Our goal is to design a feasible actuator that uses the magnetostrictive properties of Terfenol-D
- The main objectives are to minimize actuator size, increase stroke, and reduce effect of hysteresis
- The constraints include a minimum output force and stroke, equivalent thermal expansions, budget, and temperature effects

Conclusions

- The Quality Function Deployment relates the customer needs to engineering requirements that we will use in the design
- The House of Quality demonstrates how each engineering requirement affects another
- The Gantt chart displays the project timeline and progress of each task. This will be updated throughout the duration of the project
- There is research currently being conducted on magnetostrictive materials and applications to actuators

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